



## ***Brayton Solar Power Conversion System***

Prepared for DOE - SAI Annual Review.  
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# Presentation requirements

- Project Objective as stated in project SOPO.
- Timeline including all subtasks as laid out in SOPO for all phases, with completion dates for previously completed work and project completion dates for future work.
- Milestones for each phase of the project.
- Significant challenges, hang-ups, breakthroughs and/or accomplishments achieved up to current working point.
- Include work planned for the next 6-12 months

## Project Outline- *Brayton Solar Power Conversion System*

- Budget Period 1 (Jan. 2008, Jan., 2009)
  - Detailed design and manufacturing package, long lead.
- Budget Period 2 (March, 2009 – December 2009 – extended to June 2010)
  - Manufacturing drawings
  - Procurement
  - Fab & lab-test PCU components
  - Fab & field test solar receiver
  - Fab & test 320 sq.m. dish (
- Budget Period 3 (June 2010- Dec. 2010)
  - Full dish-system assembly and tests

# Budget Period-1

<b>Task#</b>	<b>Task</b>	<b>Milestone</b>
<b>1.1</b>	<b>Turboalternator-detailed thermo-mechanical and life analyses</b>	<b>Support life analysis of &gt;40,000 hrs</b>
<b>1.2</b>	<b>Hybrid solar receiver detailed design</b>	<b>Detailed receiver design</b>
<b>1.3</b>	<b>Final dish size specifications</b>	<b>Dish specification report</b>
<b>1.4</b>	<b>Update design package and BOM for cost analysis and LCOE</b>	<b>Bill of materials, system cost analysis, LCOE</b>
<b>1.5</b>	<b>Project Management and Reporting</b>	<b>Monthly and quarterly reports, Final Design Report (216 pages)</b>
<b>M1</b>	<b>Final Design Report (216 pages)</b>	<b>Acceptance from DOE</b>

# Budget Period-2

Task#	Task Description	Milestone
2.0	Continuation report	Revise and update BP#1 report to address SNLA issues:
2.1	Demonstrate turbine efficiencies	Experimentally verify a turbine efficiency $>0.80$ (*1)
2.2	Demonstrate alternator efficiencies	Experimentally verify a turbine efficiency $>0.96$ (*2)
2.3	Characterize control variables	Verify that 'flatness' of the system (turboalternator) efficiency (+/- 2 pts)
2.4	Turboalternator Integrity test	Operate turboalternator for $>50$ hours
2.5	Receiver manufacturing methods and cost	Prepare receiver manufacturing description and cost model
2.6.1	Dish reviews	Host two design reviews at Dish manufacturer (one pre-build, one after test)
2.6.2	Dish and receiver test plans	Submit draft plans to National Labs for review & comment
2.6.3	Dish test	Perform characterization testing of new prototype SolarCAT dish. The National Laboratories will be given the opportunity to support and observe the characterization and testing of this dish
2.7	Receiver test	The solar receiver efficiency goal is $>86\%$ at projected gas inlet and exit temperatures, based upon a geometric dish/aperture concentration ratio of 1800.
2.8.1	Reporting, general FAR	Reports provided in accordance with the Federal Assistance Reporting guidelines.
2.8.2	Monthly technical	A detailed report in presentation format - and oral presentation
2.8.3	Final report	Summary of SOPO results and update cost models.

# Budget Period-3

<b>Task#</b>	<b>Task</b>	<b>Milestone</b>
<b>3.1</b>	<b>Finalize design and of power conversion system</b>	<b>Monthly design reviews</b>
<b>3.2</b>	<b>Procure hardware and fabricate receiver/power conversion module</b>	<b>Monthly design reviews</b>
<b>3.3</b>	<b>Install complete module</b>	<b>Installed / commissioned dish-PCU module</b>
<b>3.4</b>	<b>Perform integrated system testing</b>	<b>Provide test results</b>
<b>3.5</b>	<b>Project Management and Reporting</b>	<b>Monthly reports and final test report</b>
<b>M3</b>	<b>Demonstrate solar and hybrid operation and deliver manufacturing plan.</b>	<b>Successful demo, update LCOE projections</b>

# Budget Period-1

Task#	Task	20 08										20 09				
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1.1	Turboalternator-detailed thermo-mechanical and life analyses															
1.2	Hybrid solar receiver detailed design															
1.3	Final dish size specifications															
1.4	Update design package and BOM for cost analysis and LCOE															
1.5	Project Management and Reporting															
M1	Final Design Report (216 pages)															

# Budget Period-2

		20 09											20 10				
Task#	Task	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
2.0	Update Budget Period-1 Continuation Report.																
2.1	Demonstrate turbine efficiencies in multistage turboexpander																
2.2	Demonstrate alternator efficiencies																
2.3	Characterize control variables, using variable area turbine nozzle																
2.4	Demonstrate overall turboalternator integrity in short-term testing.																
2.5	Define receiver manufacturing methods and cost																
2.6	Dish Review, Characterization and Testing																
2.7	Characterize solar receiver performance																
2.8	Project Management and Reporting																
M2	Go/No Go report																

# Budget Period-3

			20 10						
Task#	Task	Milestone	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3.1	Finalize design and of power conversion system	Monthly design reviews							
3.2	Procure hardware and fabricate receiver/power conversion module	Monthly design reviews							
3.3	Install complete module	Installed / commissioned dish-PCU module							
3.4	Perform integrated system testing	Provide test results							
3.5	Project Management and Reporting	Monthly reports and final test report							
M3	Demonstrate solar and hybrid operation and deliver manufacturing plan.	Successful demo, update LCOE projections							

## Two products

1. SolarCAT – with compressed air energy storage
2. Dish-Brayton – stand-alone dish module

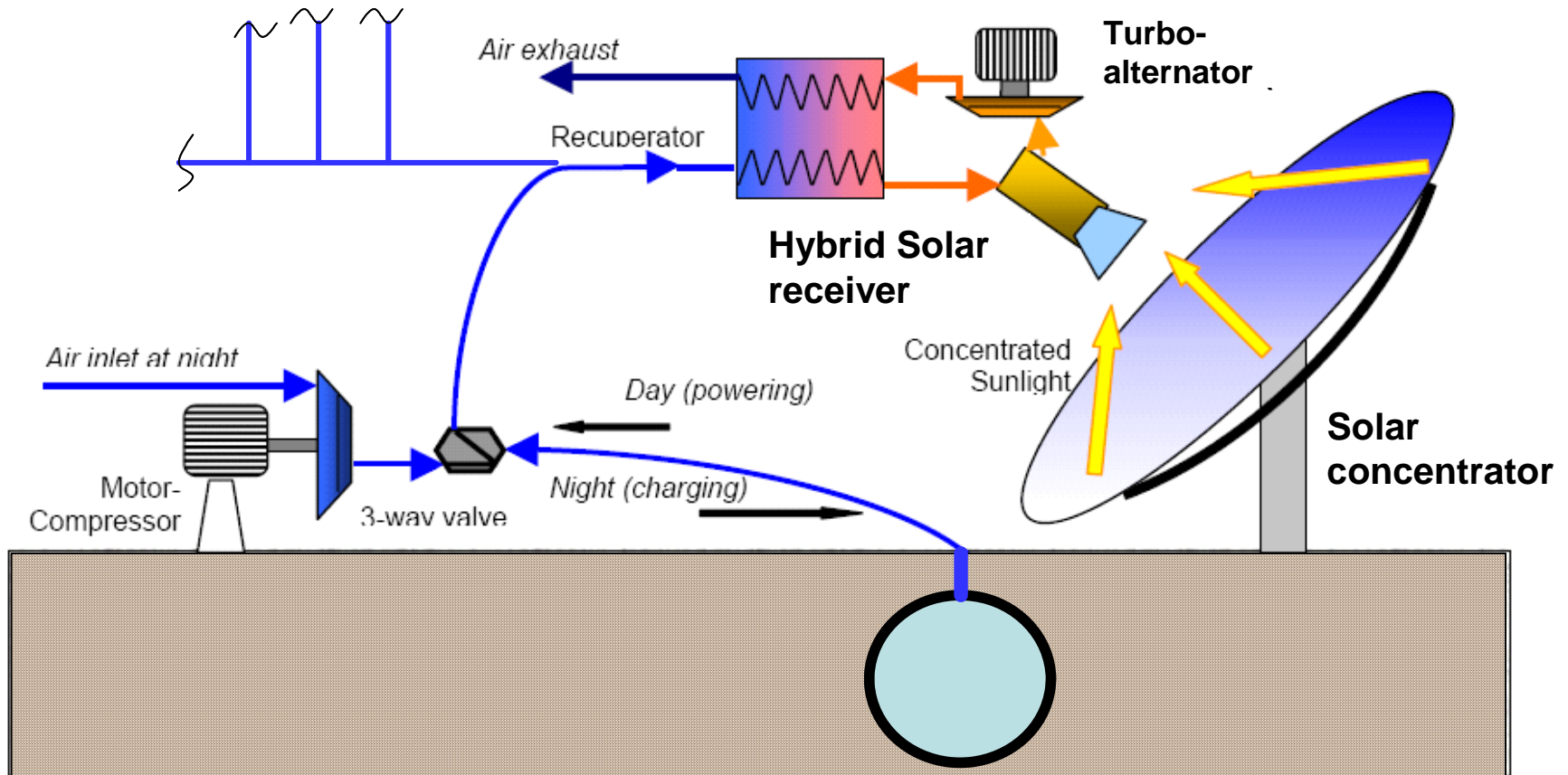
## Use common subassemblies:

- 320 sq. meter dish
- Advanced solar receiver
- Air-bearing mechanical system
- High-speed turbo-alternator

# SolarCAT Cycle Diagram with compressed air energy storage

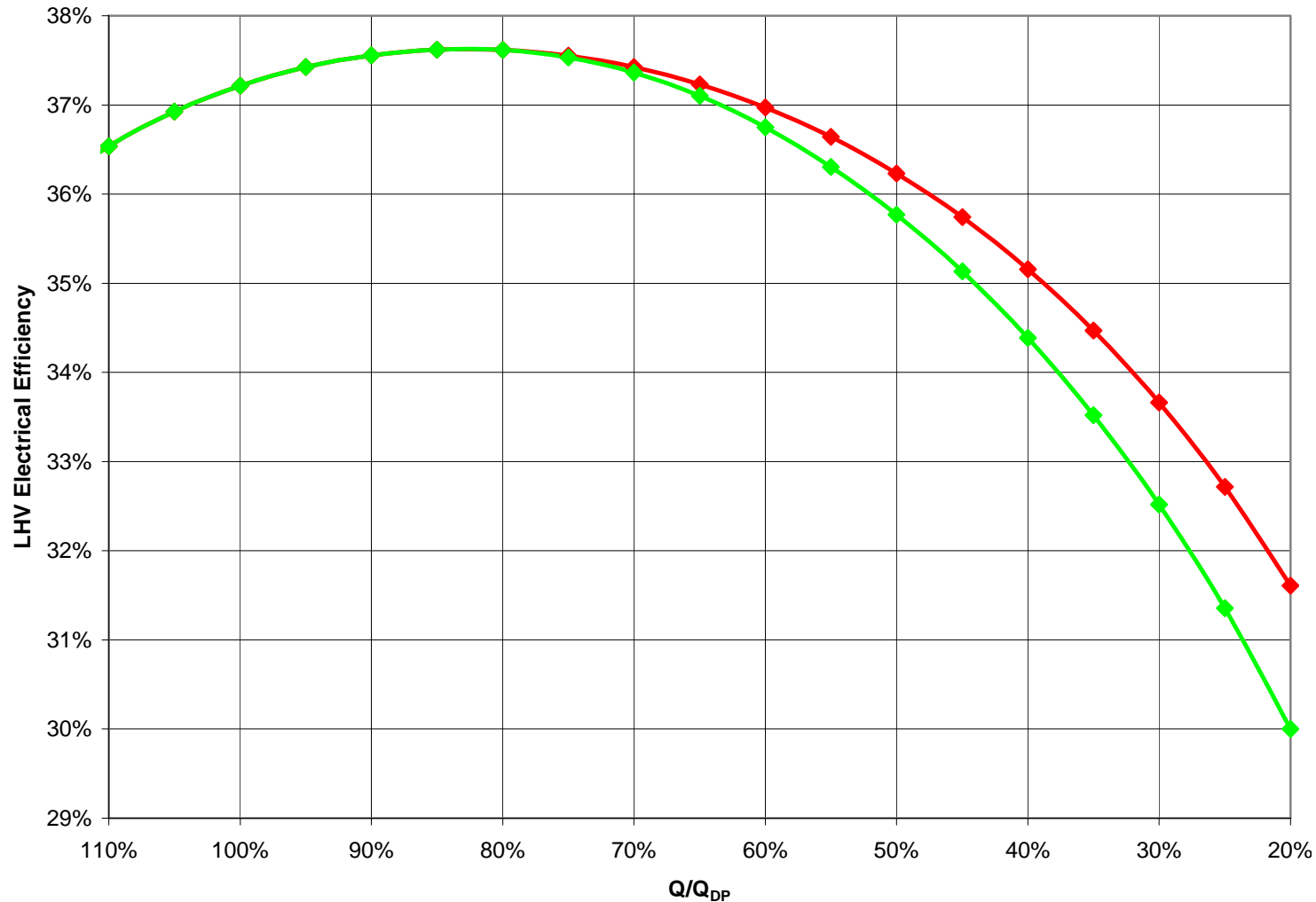
**5 to 50 Dish-modules fed  
by the central compressor  
/ storage system**

**185 kWe at 850W/m<sup>2</sup>**



# Brayton engine efficiency (thermal-AC electric) has excellent part-load efficiency

Electrical Efficiency vs %Solar

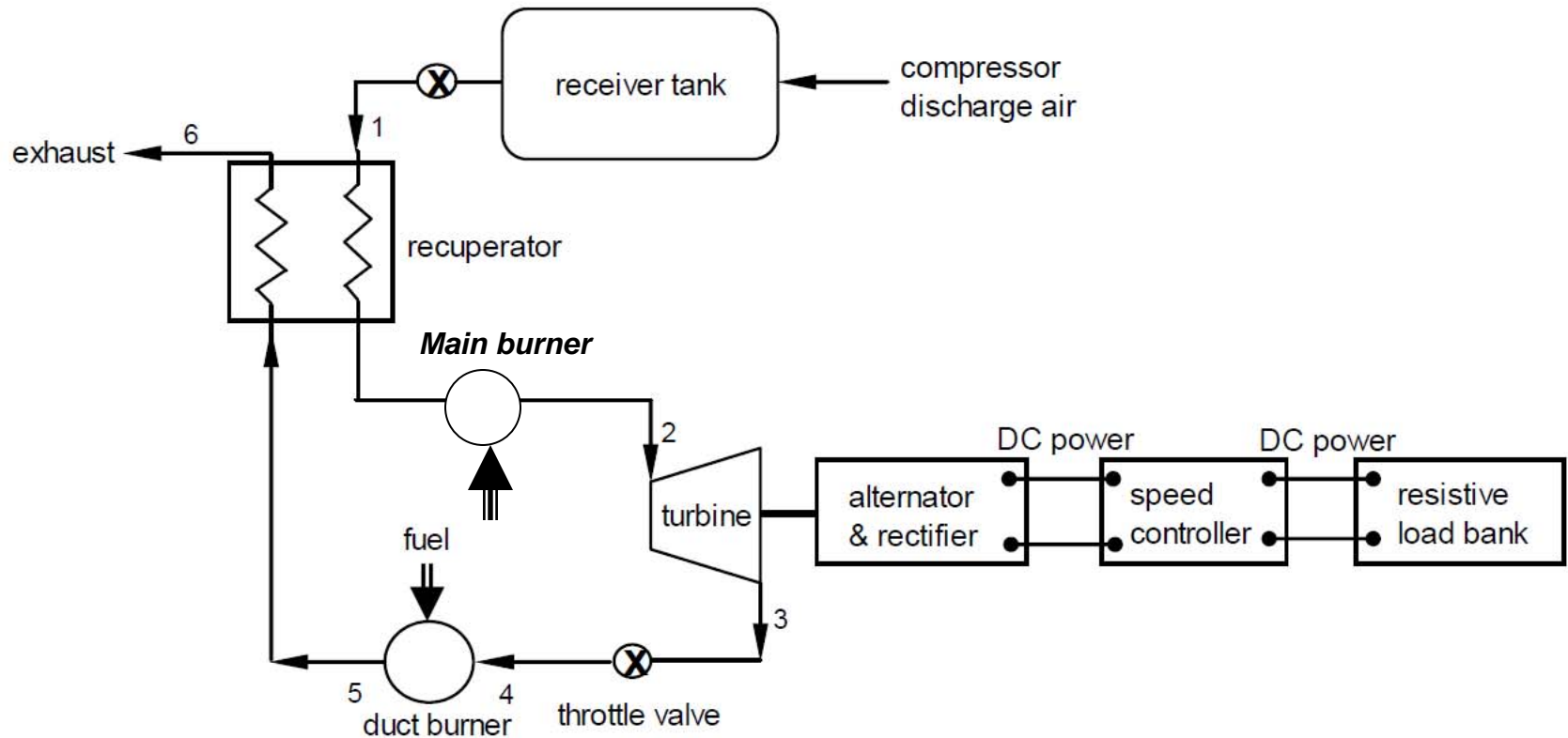


# Cavity Heat Loss Test



- The full-scale simulated cavity was covered with layers of insulation to minimize heat loss through conduction.
- Heaters were placed inside to provide 33.7 kW of power.
- Thermal couples record the cavity temperatures.
- Cavity is able to rotate 90 degrees
- This test successfully validated receiver thermal loss models

# Turbo-Alternator Stage Test Schematic

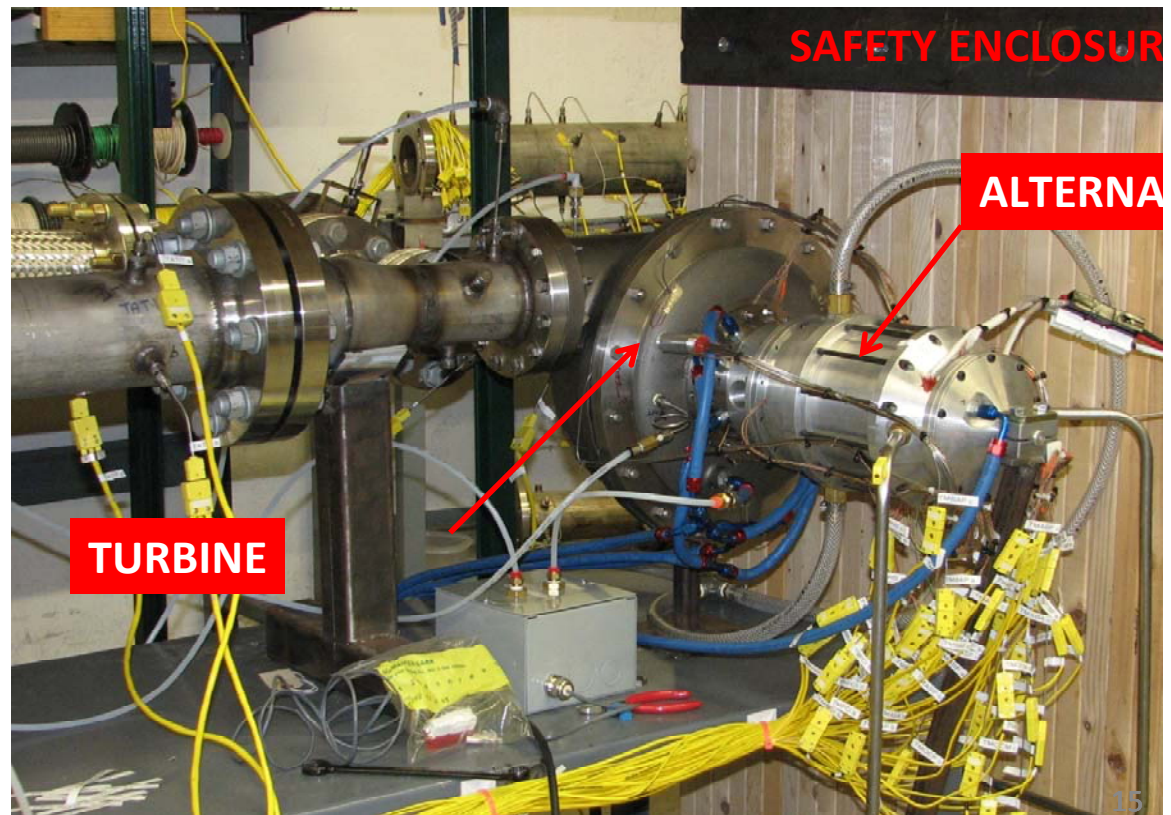


January Rig Updates: Installed main burner and extended piping distance between burner and turbine

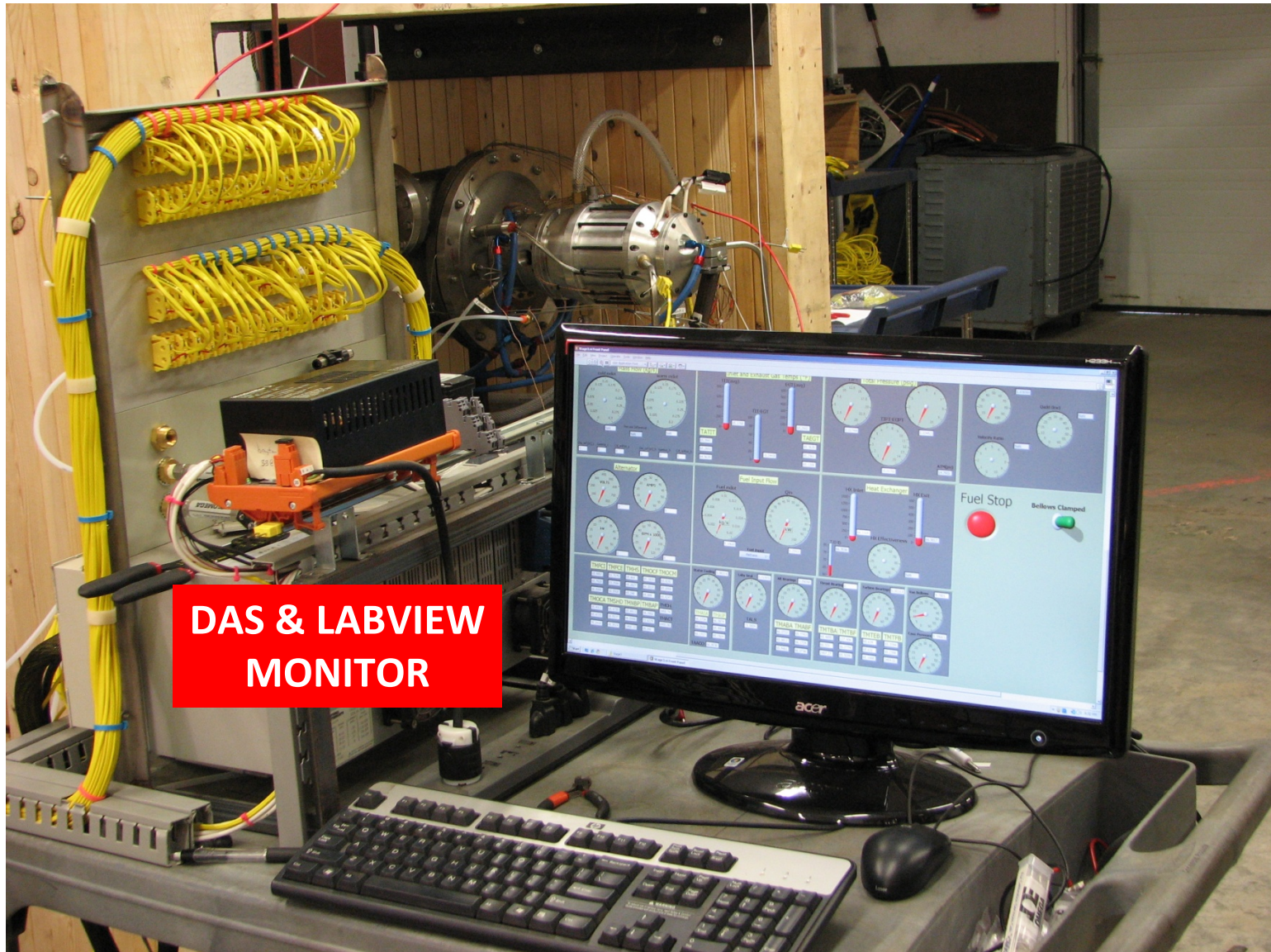
# Stages 3 and 4 Turbo-Alternator Status

## Achievements

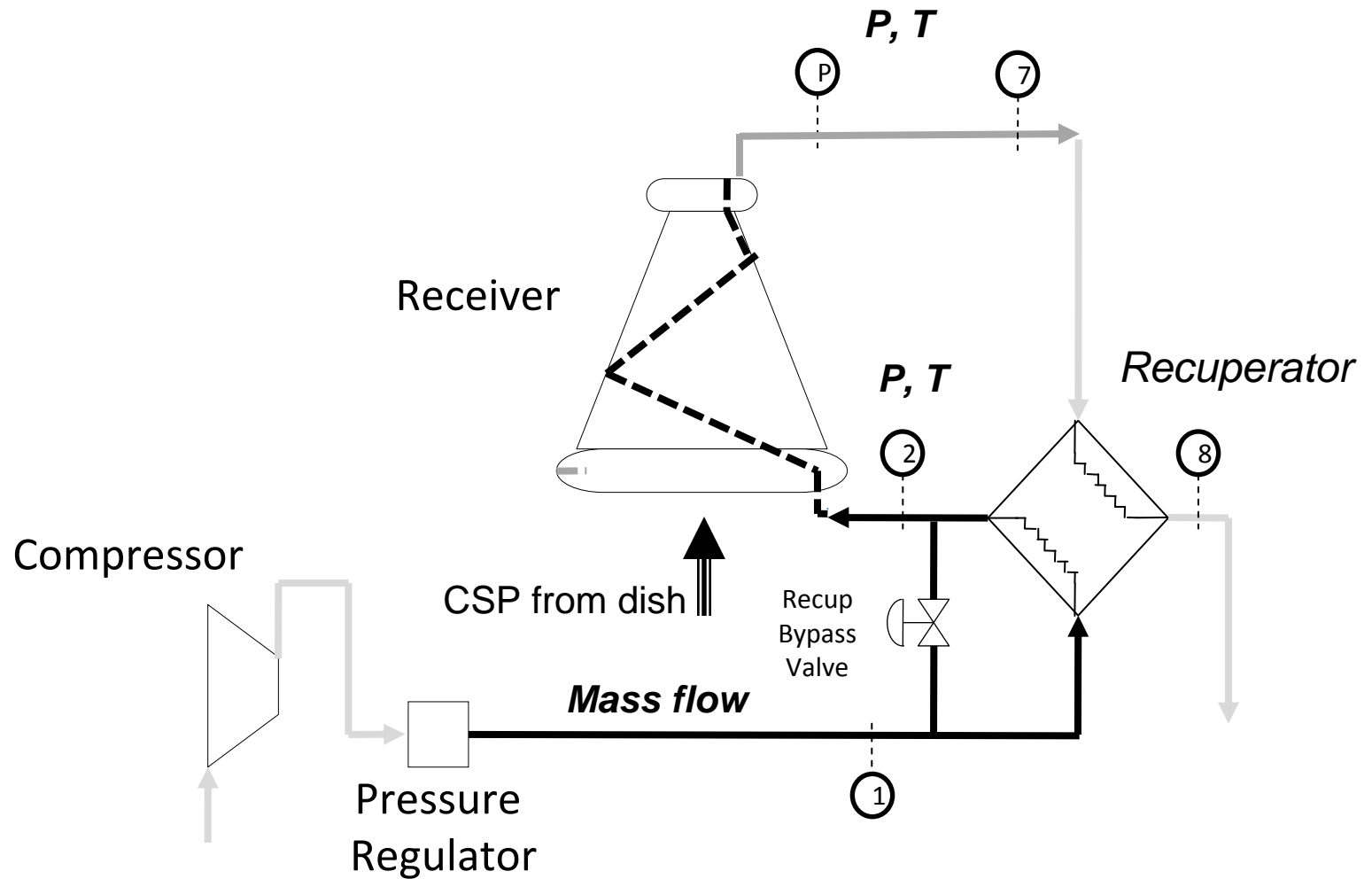
1. Commissioned recuperated/hybrid combustion rig
2. Completed rotor dynamics check-out over operating speed range
3. Performance test performed for roughly 24 test hours (roughly 15 test sequences)
4. Performance characterization ongoing



## Turbo-Alternator Test Rig - DAS



# Receiver/Dish Test Schematic





*Solar Receiver Test Rig:* prepared for dish test in April/May 2010